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Report No. 8926-127

Material - Stainless Steel - Type 410, Casting

Effect of Surface Preparation on Adhesive
Bond Strengths

H. Pearson, G. L. Picotte, E. E. Keller

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Abstract:

The comparative effectiveness of a sulfuric acid-sodium dichromate and a boiling hydrofluoric acid surface preparation in providing suitable structural adhesive bonds between Type 410 stainless steel castings, and 7075-T6 clad and 2024-T86 bare aluminum alloys was determined. The sulfuric acid-sodium dichromate cleaner consisted of distilled water, 2 per cent sulfuric acid and 2 per cent sodium dichromate used at room temperature. The hydrofluoric acid cleaner consisted of a 10 per cent aqueous hydrofluoric acid solution used at its boiling temperature for 5 minutes. The adhesives used to compare the adhesion characteristics of the different stainless steel surfaces were EC-1459 primer and AF-10 film (Minnesota Mining and Manufacturing Co.), and they were cured at 350°F for 2 hours under a pressure of 100 psi. Satisfactory adhesive bond strengths were obtained with both surface preparation methods. The hydrofluoric acid method generally provided the higher strengths, however. Pertinent results are tabulated below:

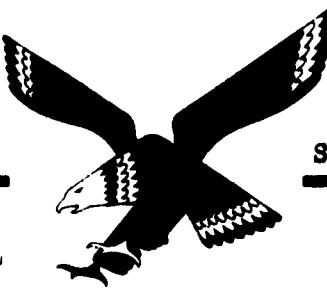
<u>Alloys (1)</u>	<u>Cleaner (2)</u>	Bond Strength		
		R.T.	SS(3)	-67°F
7075-410	1	3190	4030	2110
7075-410	2	3635	3690	2945
2024-410	1	2690	3910	1690
	2	3320	4050	2480
7075-7075	1	4015	4155	1610
2024-2024	1	3890	4165	2115
				2265

(1) 7075-T6, 2024-T86 aluminum alloys, Type 410 stainless steel.

(2) 1, sulfuric acid-sodium dichromate cleaner; 2, hydrofluoric acid cleaner.

(3) Tested at room temperature after 30 days salt spray exposure.

Reference: Pearson, H., Picotte, G. L., Keller, E. E., "Aluminum to Stainless Steel Bond Tests," General Dynamics/Convair Report MP 57-603, San Diego, California, 30 December 1957 (Reference attached).



STRUCTURES-MATERIALS LABORATORIES

REPORT 57-603

DATE 12-30-57

MODEL F-106A

TITLE

REPORT NO. 57-603
ALUMINUM TO 410 STAINLESS
STEEL BOND TESTS

MODEL: F-106A

CONTRACT: AF33(600) 30169

PREPARED BY H. Pearson
H. Pearson

GROUP MATERIALS & PROCESSES LAB.

CHECKED BY G. L. Picotte
G. L. Picotte

REFERENCE _____

CHECKED BY E. E. Keller
E. E. Keller

APPROVED BY E. F. Strong
E. F. Strong,
Chief of Test Laboratories

CHECKED BY W. M. Sutherland
W. M. Sutherland NO. OF PAGES 7

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ACCESS NO.

Title: MATERIAL - STAINLESS STEEL - TYPE 410, CASTING. EFFECT OF SURFACE PREPARATION ON ADHESIVE BOND STRENGTHS.

Authors: Pearson, H., Picotte, G. L., Keller, E. E.

Report No. 8926-127

Date: 30 December 1957

Contract: AF 33(600)-30169

Contractor: General Dynamics/Convair

ABSTRACT: The comparative effectiveness of a sulfuric acid-sodium dichromate and a boiling hydrofluoric acid surface preparation in providing suitable structural adhesive bonds between Type 410 stainless steel castings, and 7075-T6 clad and 2024-T86 bare aluminum alloys was determined. The sulfuric acid-sodium dichromate cleaner consisted of distilled water, 2 per cent sulfuric acid and 2 per cent sodium dichromate used at room temperature. The hydrofluoric acid cleaner consisted of a 10 per cent aqueous hydrofluoric acid solution used at its boiling temperature for 5 minutes. The adhesives used to compare the adhesion characteristics of the different stainless steel surfaces were EC-1459 primer and AF-10 film (Minnesota Mining and Manufacturing Co.), and they were cured at 350°F for 2 hours under a pressure of 100 psi. Satisfactory adhesive bond strengths were obtained with both surface preparation methods. The hydrofluoric acid method generally provided the higher strengths, however Pertinent results are tabulated below:

(see next card)

ACCESS NO. (Continued)

Title: MATERIAL - STAINLESS STEEL - TYPE 410, CASTING. EFFECT OF SURFACE PREPARATION ON ADHESIVE BOND STRENGTHS.

Alloys (1)	Cleaner (2)	Bond Strength			
		R.T.	SS(3)	-67°F	300°F
7075-410	1	3190	4080	2110	2275
7075-410	2	3635	3690	2945	1620
2024-410	1	2690	3910	1690	1670
	2	3320	4050	2480	1560
7075-7075	1	4015	4155	1610	2145
2024-2024	1	3890	4165	2115	2265

(1) 7075-T6, 2024-T86 aluminum alloys, Type 410 stainless steel.

(2) 1, sulfuric acid-sodium dichromate cleaner;
2, hydrofluoric acid cleaner.

(3) Tested at room temperature after 30 days salt spray exposure.

ANALYSIS
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REPORT NO. 57-603
ALUMINUM TO 410 STAINLESS
STEEL BOND TESTS

INTRODUCTION:

In accordance with a letter from AMC, substantiation of the stainless steel surface treatment described in paragraphs 3.2.2.4 and 3.2.2.5 of Convair Specification 8-01318 was deemed necessary. The relative effect of cleaning with sulfuric acid-sodium dichromate type solutions and of hydrofluoric acid cleaners on bond strength was desired. The stainless steel alloy to be tested was Type 410 in cast form.

OBJECT:

To evaluate present stainless steel cleaning methods on Type 410 cast stainless steel in accordance with Convair Specification 8-01318.

CONCLUSION:

Satisfactory results were obtained with both the sulfuric acid-sodium dichromate and hydrofluoric acid surface treatment systems. The hydrofluoric acid method specified in 3.2.2.5 is the better of the two systems in regards to bond strength.

RECOMMENDATION:

Some thought should be given to the necessary strength requirements before establishing a production line surface treatment system on this type steel. Even though slightly higher tensile shear values are obtained by the alternate cleaning method, it would be considerably more hazardous in operation. The use of boiling hydrofluoric acid in the cleaning procedure would necessitate the use of special cleaning tanks and severe safety precautions. Possibly the loss in bond strength could be sacrificed to allow for ease in handling.

DESCRIPTION OF SPECIMENS:

The specimens were of the lapped tensile shear type. One half of each test specimen was aluminum and the other half steel. The aluminum half specimens consisted of two types. These were .064" 7075-T6 clad and .064 2024-T86 bare aluminum alloys. They were cut and subsequently milled to one by four inch dimensions. These will hereafter be referred to as type "A" and type "B" aluminum respectively.

The steel half of specimens were cut from four F-106 rudder horns. It was found that by making some of the samples slightly less than the desired one by

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DESCRIPTION OF SPECIMENS: (Continued)

four inch size, forty-one pieces .051" thick could be obtained. During the milling operation both sides of the specimens were given a 125 microinch finish.

A duplicate set of aluminum to aluminum specimens were prepared for control purposes.

TEST PROCEDURE:

The aluminum half of test specimens were cleaned with dichromate-sulfuric acid cleaning solution as set forth in paragraph 3.2.2.1 of Specification 8-01318, oven dried for 20 minutes at 175° F, allowed to cool to room temperature and primed with EC 1459, LOT 16H6S. The specimens were then air dried for 15 minutes at room temperature and precured 30 minutes in a circulating air oven at 250° F, preparatory for bonding.

The steel half of test specimens were divided into two groups. One group was cleaned in accordance with paragraph 3.2.2.4 of Specification 8-01318 and shall be referred to as type 1. The other group was cleaned by the method specified in paragraph 3.2.2.5 of Specification 8-01318 and shall be called type 2. Both sets of specimens were then dried and primed in the same manner as were the aluminum specimens described above.

A special jig, see Figure 1, was fabricated to hold the specimens in place during the bonding operation. This fixture maintained the overlap distance as well as the alignment of the two half specimens. All specimens were bonded with AF 31, LOT 24 adhesive at 350° F ± 10° F for 2 hours ± 5 minutes and at a pressure of 100 psi ± 5, according to the procedure set forth in Convair Specifications 8-01318 and 0-03007.

The bonded specimens were of four kinds; type "A" aluminum bonded to type 1 and 2 steel and type "B" aluminum bonded to type 1 and 2 steel. Hereafter in this report these test specimens will be referred to by the following designations; A₁, A₂, B₁, and B₂ respectively. Each type of specimen was tested as follows: room temperature, room temperature after thirty days exposure to salt spray, minus 67° F. and plus 300° F. The specimens subjected to salt spray exposure were tested within two hours after their removal from the environmental cabinet. The salt spray exposure was done in accordance with Specification QQ-M-151.

All testing was done on a Tinius Olsen testing machine with appropriate attachments.

RESULTS:

The results of tensile shear tests are recorded in Tables 1, 2, 3, and 4.

Note: The 300° F tensile shear values given in Tables 1 and 2 are low due to a mechanical failure of the testing machine.

The data from which this report was prepared are recorded in Data Book No. 891.

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TABLE 1

7075-T6 CLAD ALUMINUM-TYPE 1 AND TYPE 2 STEEL

SPEC TEST	TEST TEMP	WEIGHT	DIAMETER	1.05 INCHES	PSI	TESTS	TEST TEMP	WEIGHT	DIAMETER	1.05 INCHES	PSI	TESTS		
1A1 RT	RT	0.91	0.50	12.70	2600	100	-	1A2 RT	RT	0.99	0.50	1895	3710	25
2A1 RT	RT	0.99	0.50	156.5	3140	75	25	2A2 RT	RT	1.00	0.51	2090	3940	40
3A1 RT	RT	0.99	0.50	156.0	3155	90	10	3A2 RT	RT	0.97	0.51	1905	3950	50
4A1 RT	RT	1.00	0.50	196.0	3840	100	-	4A2 RT	RT	0.97	0.50	1520	3140	85
AVE				31.90				AVE					3635	
5A1 RT	RT	0.99	0.52	22.80	4432	95	5	5A2 RT	RT	1.00	0.52	2100	4038	90
6A1 RT	RT	1.00	0.51	182.5	3520	90	10	6A2 RT	RT	1.00	0.52	1905	3660	65
7A1 RT	RT	0.99	0.51	220.5	4360	90	10	7A2 RT	RT	0.98	0.51	1905	3610	95
8A1 RT	RT	0.99	0.50	194.5	3930	95	5	8A2 RT	RT	1.00	0.53	1955	3690	55
AVE				40.80				AVE					3750	
9A1 -27°F	1.00	0.51	11.70	2220	100	-	9A2 -67°F	1.00	0.51	1400	2800	100	-	
10A1 -67	1.00	0.51	12.20	2332	100	-	10A2 -67	1.00	0.50	1310	2620	100	-	
11A1 -67	1.00	0.50	106.0	2120	100	-	11A2 -67	1.00	0.51	1665	3262	100	-	
12A1 -67	1.00	0.50	180	1660	100	-	12A2 -67	1.00	0.51	1580	3100	100	-	
AVE				211.0				AVE					2945	
13A1 300°F	1.00	0.50	11.35	2270	-	100	13A2 300°F	0.98	0.50	750	1530	-	100	
14A1 300	1.00	0.50	11.20	2240	-	100	14A2 300	0.97	0.50	730	1500	-	100	
15A1 300	1.00	0.50	124.5	2492	-	100	15A2 300	0.98	0.51	835	1670	-	100	
16A1 300	1.00	0.50	1050	2100	-	100	16A2 300	1.00	0.51	915	1790	-	100	
AVE				227.5				AVE					1620	

* RT - 27°F - TYPE 1 AT ALL
ADH - ADHESIVE TEST
COP - CORROSION TEST
SPOT - SPOT EROSION TEST

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TABLE 2
2024-T86 BARE ALUMINUM - TYPE 1 AND TYPE 2 STEEL

SPEC	TEST TEMP	WEIGHT GROSS LBS	LENGTH INCHES	LBS ULTIMATE LOAD	PSI ULTIMATE STRENGTH	FALLING LOAD	TEST TEMP	WEIGHT GROSS LBS	LENGTH INCHES	LBS ULTIMATE LOAD	PSI ULTIMATE STRENGTH	FALLING LOAD
1B, RT	0.99	0.50	1235	2500	70	30	10 ₁ , RT ₁	1.00	0.50	1545	3090	20
2B, RT ₁	1.00	0.51	1505	2950	60	40	2B ₁ , RT ₁	0.99	0.48	1240	2610	100
3B, RT ₁	1.00	0.49	1360	2780	50	50	3B ₁ , RT ₁	1.00	0.52	1960	3770	90
4B, RT ₁	1.00	0.49	1210	2520	100	-	4B ₁ , RT ₁	0.99	0.50	1730	3500	60
AVE			2690	4000	100	-	AVE			3320		
5B, RT	1.00	0.51	2040	3830	90	10	5B ₂ , RT	0.99	0.50	2040	4160	75
6B, RT	1.00	0.51	1955	3800	90	10	6B ₂ , RT	0.99	0.53	1985	3780	95
7B, RT	1.00	0.50	2000	4000	100	-	7B ₂ , RT	0.99	0.53	2060	3920	100
8B, RT	0.99	0.50	1990	3820	100	-	8B ₂ , RT	1.00	0.50	2170	4340	85
AVE			3910	4045	100	-	AVE			4050		
9B ₁ , -67°F	1.00	0.51	1145	2240	100	-	9B ₂ , -67°F	1.00	0.51	1605	3150	100
10B ₁ , -67	1.00	0.48	700	1460	100	-	10B ₂ , -67	1.00	0.50	1215	2430	100
11B ₁ , -67	1.00	0.48	780	1630	100	-	11B ₂ , -67	1.00	0.50	1105	2215	100
12B ₁ , -67	0.98	0.52	730	1430	100	-	12B ₂ , -67	0.99	0.50	1230	2480	100
AVE			1690	1670	100	-	AVE			2555		
13B ₁ , 300°F	0.99	0.50	925	1670	-100		13B ₂ , 300°F	0.98	0.48	790	1680	-100
14B ₁ , 300	1.00	0.50	925	1770	-100		14B ₂ , 300	1.00	0.50	815	1630	-100
15B ₁ , 300	0.99	0.50	900	1620	-100		15B ₂ , 300	1.00	0.50	820	1440	-100
16B ₁ , 300	0.97	0.50	780	1610	-100		16B ₂ , 300	0.97	0.50	620	1280	-100
AVE			1670				AVE			1560		

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TABLE 3

7075-T6 CLAD ALUMINUM CONTROL SPECIMENS

SPEC	TEST TEMP	WIRE GAGE	TEST LENGTH	LOS	INTENSTI	TESTATION	PSI	FAILURE
1A RT	1.00	0.30	1920	9240	-	100	1.00	0.30
2A RT	1.00	0.50	2005	4010	-	100	1.00	0.49
3A RT	1.00	0.51	2115	4140	-	100	1.00	0.50
4A RT	1.00	0.50	1920	3840	5	95	20A	-67
5A RT	1.00	0.50	2045	4090	-	100	21A	-67
6A RT	1.00	0.51	2170	4240	-	100	22A	-67
7A RT	1.00	0.51	2155	4210	-	100	23A	-67
8A RT	1.00	0.50	1985	3970	-	100	24A	-67
9A RT	1.00	0.50	2005	4010	-	100	AVE	
10A RT	0.99	0.50	1925	3780	-	100	25A	300°F
AVE							1.00	0.49
11A RT	1.00	0.50	2005	4010	100	-	26A	300
12A RT	0.98	0.51	1995	3920	100	-	27A	300
13A RT	1.00	0.50	2170	4240	100	-	28A	300
14A RT	1.00	0.50	2190	4360	20	10	29A	300
15A RT	1.00	0.50	2170	4360	95	5	30A	300
16A RT	1.01	0.50	1860	3910	100	-	AVE	
AVE							1.00	0.50
							4/53	

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TABLE 4

2024-T86 BARE ALUMINUM CONTROL SPECIMENS

SPEC	TEST	TEMP	WIDTH	LENGTH	LBS	PSI	CAUSE	TEST			WIDTH	LENGTH	LBS	PSI	CAUSE
								SPEC	TEMP	TIME					
1B	RT	1.00	0.50	1920	3940	10	90	17B	-67°F	1.00	0.49	1025	2138	100	-
2B	RT	1.00	0.50	1895	3790	5	95	18B	-67	1.00	0.48	1030	2144	100	-
3B	RT	1.00	0.50	1985	3920	50	50	19B	-67	1.00	0.49	1585	3238	100	-
4B	RT	1.00	0.50	1905	3810	30	70	20B	-67	1.00	0.50	900	1800	100	-
5B	RT	1.00	0.50	2095	4070	25	75	21B	-67	1.00	0.50	1060	2120	100	-
6B	RT	1.00	0.50	1850	3700	-	100	22B	-67	1.00	0.50	1010	2020	100	-
7B	RT	1.00	0.50	1890	3780	35	65	23B	-67	1.00	1.49	705	1440	100	-
8B	RT	1.00	0.50	2030	4060	20	80	24B	-67	1.00	0.50	1005	2010	100	-
9B	RT	1.00	0.50	2020	4040	30	70	AVE						2115	
10B	RT	1.00	0.50	2015	4030	-	100	25B	300°F	1.00	0.50	1140	2280	-100	
11B	RT	1.00	0.51	2130	4160	90	10	26B	300	1.00	0.50	1095	2190	-100	
12B	RT	1.00	0.51	2185	4280	90	10	27B	300	1.00	0.52	1300	2500	-100	
13B	RT	1.00	0.50	1910	3820	100	-	28B	300	1.00	0.50	1125	2250	-100	
14B	RT	1.00	0.50	2080	4160	100	-	29B	300	1.00	0.50	1110	2220	-100	
15B	RT	1.00	0.50	2020	4200	100	-	30B	300	1.00	0.50	1075	2130	-100	
16B	RT	1.00	0.50	2185	4320	95	15	AVE						2265	
															4165

Convinia
Jan Dugan

ANALYSIS
PREPARED BY
CHECKED BY
REVISED BY

Pearson/Picotte
Keller/Sutherland

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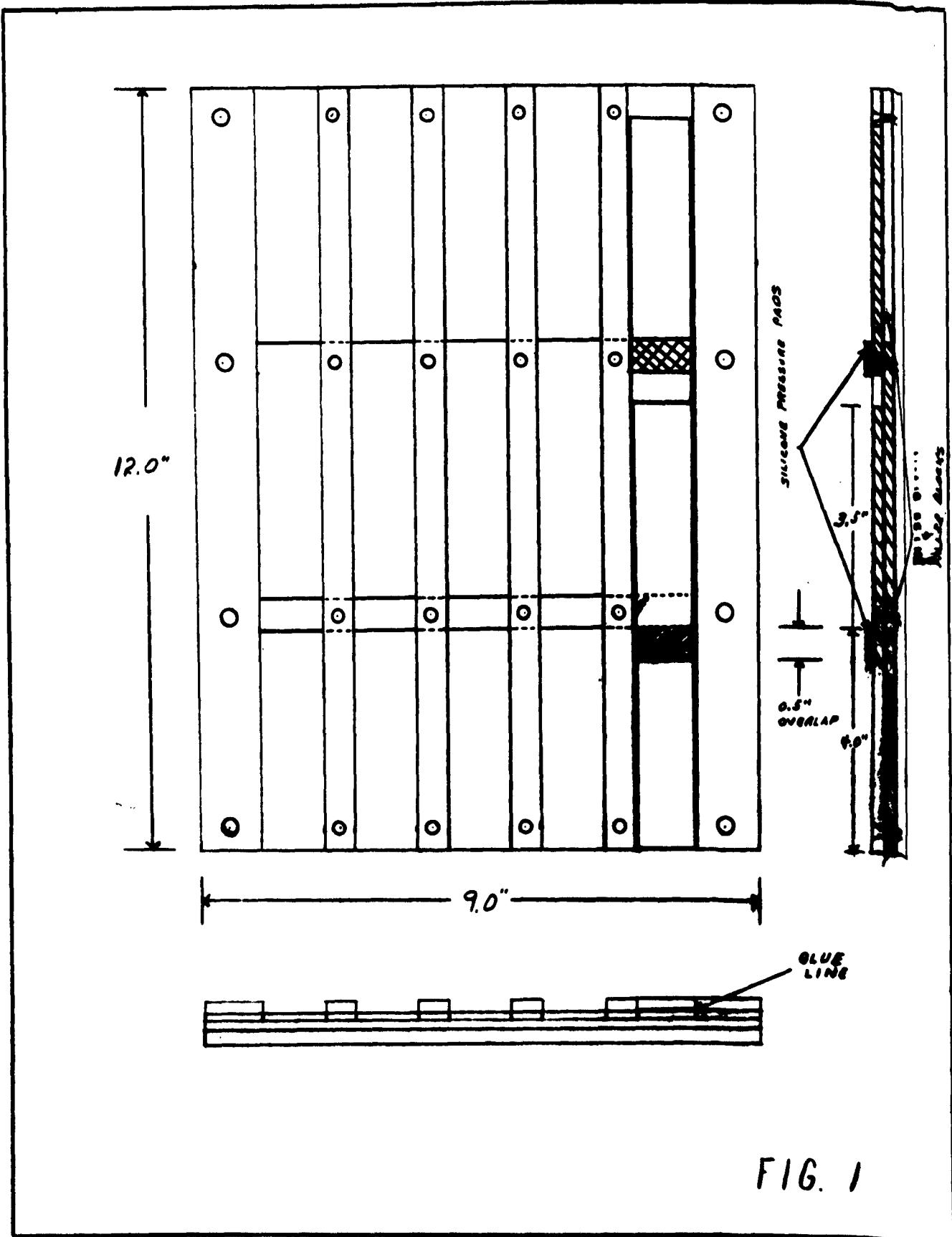


FIG. 1